

Sands (H.B.)

ESMARCH'S  
BLOODLESS METHOD.

BY  
HENRY B. SANDS, M. D.,  
NEW YORK.

(1)

[REPRINTED FROM THE NEW YORK MEDICAL JOURNAL, JAN., 1875.]

NEW YORK:  
D. APPLETON AND COMPANY,  
[549 & 551 BROADWAY.  
1875.

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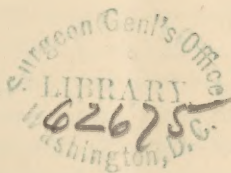
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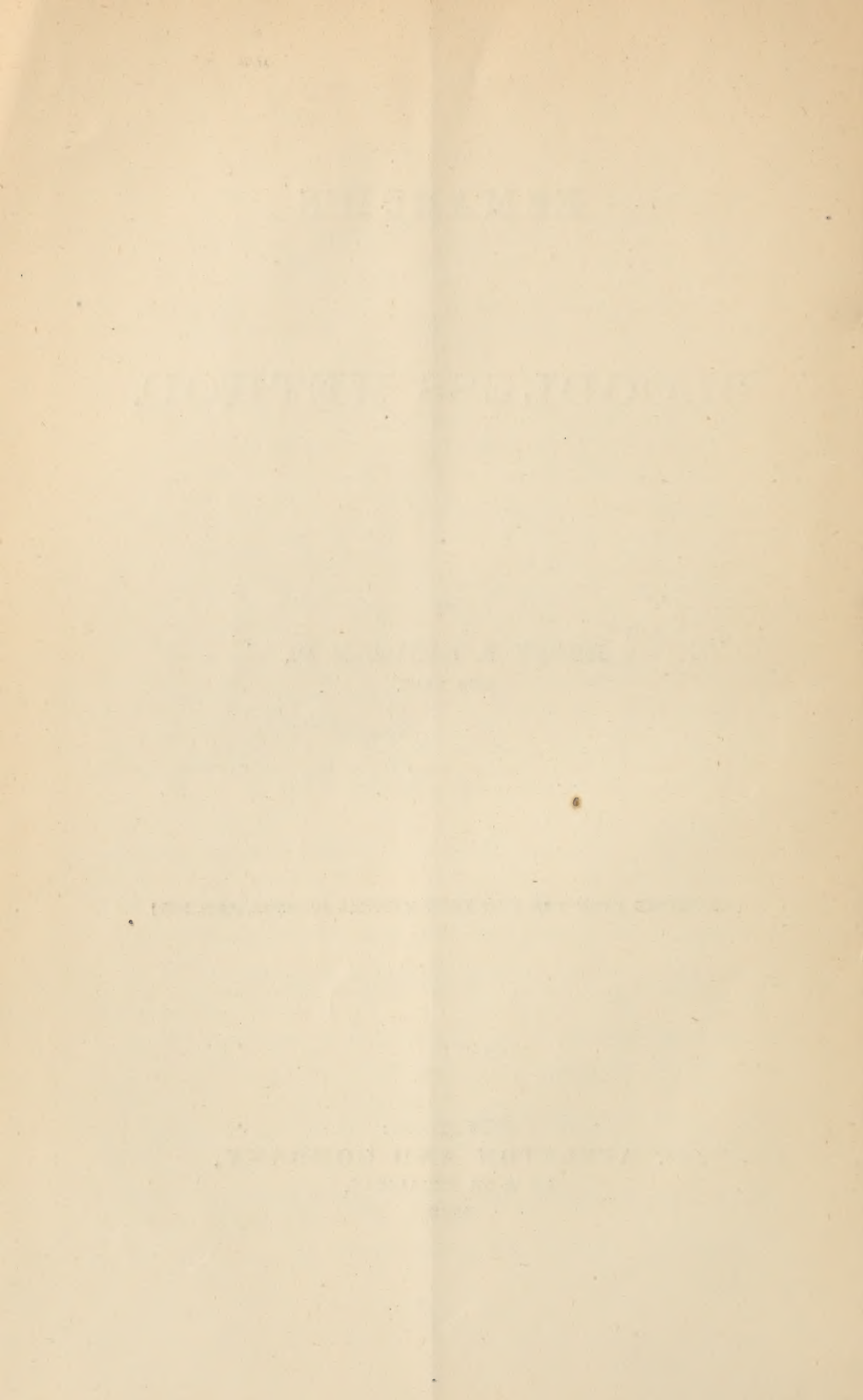
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A. E. Mc Purdy*

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## ESMARCH'S BLOODLESS METHOD.<sup>1</sup>

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IN April, 1873, at a meeting of the German Surgical Congress, in Berlin, Prof. Esmarch, of Kiel, announced an important discovery. He stated that, after many trials, he had ascertained the fact that, by the application of an elastic bandage to the extremities, the limbs could be rendered bloodless; and that, by the substitution of a piece of rubber tubing for the tourniquet, the condition of artificial *anæmia* produced by the bandage could be maintained, so as to permit operations to be performed upon the parts below, with even less loss of blood than if performed upon the dead body. Such an announcement could not fail to excite surprise; and surgeons, both in Europe and America, hastened to test the accuracy of the statements made by the German teacher. In the present paper I have endeavored to form an appreciation of the value of Esmarch's method, by studying the experience which the surgeons of New York and its vicinity have had in its employment during the year that has passed since it was first put upon trial here. And I may remark, incidentally, that whatever value the method may be found to possess, must fairly be ascribed to Esmarch himself, and not to his prede-

<sup>1</sup> Read, November 23, 1874, at the anniversary meeting of the Medical Society of the County of New York, by H. B. Sands, M. D., President of the Society.

cessors. Attempts have been made, especially in England, to prove that the method is no novelty, either in principle or in detail, and that the same results had often been obtained by the use of an ordinary bandage and a tourniquet. But, although it must be admitted that the principle is an old one, the successful application of it is unquestionably due to the employment of the elastic bandage, as recommended by Esmarch. To any one who compares the action of an ordinary with that of an elastic bandage, in the production of artificial anæmia, the superiority of the latter is at once apparent. Indeed, the novelty of Esmarch's method is shown by the fact, that the old method, owing to its imperfections, had wellnigh fallen into oblivion; while the new one has excited an interest and enthusiasm in the surgical world which have not been equaled since the introduction of anæsthetics.

For the information of those who are not yet familiar with the details of the bloodless method, it will be desirable, first, to describe the mode and range of its application. Secondly, we may state its alleged advantages and disadvantages; and, finally, endeavor to estimate its value as tested by our own experience.

The bandages are composed of elastic webbing, or—what is better—of simple sheet-rubber, which can be more readily cleaned than the webbing, when it has become soiled by pus or other discharges. The bandages should be about two and a half inches wide, and it is convenient to be provided with several of them, each three yards in length, rather than to employ one long bandage. As a substitute for the tourniquet, some surgeons use a piece of the same bandage; others employ a solid rubber cord or rope, about a quarter of an inch in diameter; while Esmarch himself recommends for this purpose a piece of tubing made of non-vulcanized rubber, which is softer and more yielding than the other varieties. The application of the bandage, in ordinary cases, is quite simple. It is put on with moderate compressing force, and carried from the fingers or the toes to any desired height. The constricting cord or tube, which is to take the place of the tourniquet, is then wound two or three times around the limb,



immediately above the upper edge of the bandage, and made fast either by a knot, or by a hook and chain, or any similar contrivance. The bandage is then removed to expose the parts for operation. Some experience is needful to apply the bandage with the proper degree of force. Often it is applied too firmly, and this mistake is pretty sure to be made by beginners. On the other hand, it may be applied too loosely, and I have several times seen it put on with just sufficient force to allow venous congestion of the parts, with consequent hæmorrhage during the operation. The same remark applies, with equal truth, to the use of the constricting cord, which, if applied too loosely, will cause venous engorgement, and, if too tightly, may do serious damage to the nerves, and probably also to the blood-vessels of the limb.

The skin, when exposed after the removal of the bandage, is seen to be blanched and anæmic; and, when the deeper tissues are cut into, they are found to be nearly or quite bloodless. The vessels, both arterial and venous, are almost absolutely empty, so that an amputation of the thigh, for example, can be performed without the loss of more than five or ten drops of blood. This bloodless condition remains unaltered so long as the constricting band is kept in position. Immediately after this has been removed, however—the large vessels having been previously secured—the blood returns to the parts with considerable force, and, if these are vascular, a pretty free oozing commonly takes place from the surface of the wound. This bleeding is usually quickly checked by the use of cold water, aided, if necessary, by gentle pressure.

With slight modifications in the adaptation of the apparatus, the bloodless method is applicable to amputation at the hip or the shoulder joint. A case of amputation at the hip-joint has recently been reported in the London *Lancet*, by Dr. Gibb, of Newcastle, who states that only two ounces of blood were lost during the operation—this having escaped from the veins when the femoral vessels were divided. It is also stated that, in this case, no harm resulted from the pressure of a pad which was placed over the abdominal aorta. In operations upon the penis and scrotum, and in the removal of large

tumors of the breast, the method has been successfully applied. Langenbeck speaks highly also of its employment in extirpation of vascular tumors of the scalp.

The enumeration I have now given nearly completes the list of regions to which the bloodless method is applicable. It cannot be employed in operations on the trunk, or on the face and neck, where surgeons would gladly, if possible, avail themselves of its advantages.

These advantages, as claimed by Esmarch, are as follow : First, the prevention of a great loss of blood during the larger operations. It is assumed that this economy of the vital fluid will sometimes be the direct means of saving life ; that it will render more certain and speedy the healing process, and diminish the frequency of septicæmia and pyæmia. The other principal advantage of the method is the facility with which it enables the surgeon to accomplish deep and difficult dissections, the tissues not being obscured by blood. It is said also to permit the easy extraction of foreign bodies, and the thorough examination of diseased bones and joints, with the view of deciding upon the extent of operation necessary in any given case.

The following objections have been made to the bloodless method. It is alleged that the pressure impairs the vitality of the parts, and causes them, in many instances, to slough. Also, that it affects injuriously the nerve-trunks, giving rise to paralysis, both of sensation and motion. Hæmorrhage, occurring shortly after the operation, has been ascribed to the method. Its employment is also thought to be dangerous, because it may induce plethora of the internal organs, by driving back into the blood-vessels a larger amount of blood than they normally contain. It is feared that the vessels, if brittle from disease, might be ruptured from this cause. Lastly, it is believed that in cases of gangrene, or unhealthy suppuration, poisonous fluids may be pressed into the blood-vessels, or into the healthy tissues, by the elastic bandage, and thus occasion septicæmia or pyæmia.

In a second paper lately written by Esmarch, that surgeon gives the results of two hundred bloodless operations per-



formed by him during the preceding year; and these results show the method in a most favorable light. As our own experience, however, is that on which we must rely, I proceed at once to a brief analysis of the cases which I have been able to obtain. They have been collected from the principal hospitals of New York, Brooklyn, and Jersey City, and from the private practice of Drs. Wood, Krackowizer, Gouley, Ely Weber, Little, Varick, and myself. The records of Charity Hospital are not included in my table, as they were so imperfectly kept that no use could be made of them. I have also failed to obtain the experience of St. Francis's Hospital in this city, where more than twenty bloodless operations are said to have been performed. I have endeavored to present all of the hospital cases, both good and bad; and, although some of the histories are imperfect, they present many interesting and instructive details. The list embraces one hundred and forty-three cases, which I have classified as follows:

	Cases.	
Amputation of fingers, primary.....	4.	
“ “ secondary or for disease.....	3.	
“ hand, partial primary.....	3.	One fatal from hæmorrhage.
“ at wrist-joint, primary.....	1.	
“ of forearm, primary.....	5.	
“ “ secondary.....	1.	
“ arm, primary.....	5.	Two fatal: one from erysipelas, one from shock.
“ “ secondary.....	1.	
“ toes, primary.....	2.	
“ foot, partial.....	1.	
“ at ankle-joint (Syme's).....	4.	
“ “ secondary.....	5.	
“ of leg, primary.....	11.	Three fatal: two from pyæmia, one from Bright's disease and exhaustion.
Double amputation of leg, primary.....	1.	Fatal from shock in forty-four hours.
“ “ secondary.....	3.	One fatal, performed for tetanus.

	Cases.	
Double amputation at knee-joint, primary...	4.	One fatal from gangrene on fourth day.
“ of thigh, primary.....	8.	Two fatal from pyæmia.
“ “ and leg, primary.	1.	
“ “ “ second'y.	9.	Three fatal: one from phthisis, one from exhaustion, and one from pyæmia.
Excision of wrist.....	3.	
“ “ primary.....	1.	
“ elbow, disease.....	3.	
“ “ primary.....	3.	
“ ankle-joint.....	2.	
“ knee-joint, disease.....	1.	Fatal from pyæmia.
“ tarsus.....	1.	Patient has symptoms of tetanus.
“ tibia, primary.....	1.	
“ femur, for ununited fracture....	1.	
Necrosis of “.....	11.	One fatal from pyæmia.
“ tibia.....	11.	
“ fibula.....	1.	
“ os calcis.....	3.	
“ scapula.....	1.	
“ humerus.....	3.	
“ radius.....	4.	
“ ulna.....	1.	
“ metacarpus.....	1.	
Ununited fracture of leg.....	1.	
Exostosis of femur.....	1.	
Removal of tumor from thigh.....	1.	
“ “ popliteal space.....	1.	
“ “ leg.....	4.	
“ “ forearm.....	1.	
Ligature of wounded ulnar arteries.....	1.	Fatal from pyæmia.
“ “ anterior tibial artery....	1.	
“ “ deep palmar arch.....	1.	
Tenotomy of hamstring.....	1.	
Excision of large mammary tumor.....	1.	
Incision of leg for varicose ulcer.....	1.	
Fistula of penis.....	1.	
Trephining abscess of tibia.....	1.	
Neuroma of stump.....	1.	
Elephantiasis arabum.....	1.	

On reviewing the above table, we find 63 amputations, excluding those of the fingers and toes. Of these operations, 44

were primary, for injury, and 19 secondary, or for disease. Of the primary amputations, 10 cases, or 22.7 per cent., terminated fatally—the causes of death being the following:

Pyæmia.....	4
Exhaustion or shock.....	3
Spreading gangrene.....	1
Erysipelas.....	1
Hæmorrhage.....	1

Of the cases fatal from pyæmia, one patient had the disease at the time of the operation.

Of 8 cases of primary amputation of the thigh, 2 cases, or 25 per cent., ended fatally.

Of 11 cases of primary amputation of the leg, 3 cases, or 27.3 per cent., were fatal.

Secondary amputations, 19 cases, give a mortality of 21 per cent. The causes of death are stated as follows:

Tetanus (existing at time of operation).....	1
Exhaustion.....	1
Phthisis.....	1
Pyæmia.....	1
Total.....	4

Although I have not the means of making an exact comparison, I believe that the percentage of recoveries in these primary amputations, which were nearly all performed on hospital patients, is somewhat larger than is commonly observed in such operations.

Out of 14 cases of excision of the joints, only one proved fatal; the cause of death being pyæmia. Another case will probably end fatally, however, as the patient was suffering from tetanus when last heard from.

Finally, the list included two more deaths, one following an operation for necrosis—the only fatal case out of 36—and the other an operation for the ligature of the ulnar artery, performed for a wound near the wrist.

These cases are not sufficiently numerous to possess much statistical value, and they do not, as I think, warrant any definite conclusions respecting the general efficiency of the bloodless method in diminishing the mortality which usually attends the larger operations. Certainly, pyæmia is not pre-



vented by it, for the greatest number of deaths are reported as due to this cause. On the other hand, it must not be assumed that the elastic bandage is responsible for the pyæmic cases, for, so far as I have been able to learn, the application of the bandage to gangrenous and putrefying parts has been carefully avoided. It is interesting to observe that no serious results appear to have ensued from the forcing back of blood into the vessels of the trunk, although the quantity of blood thus added, as it were, to the circulation, must, in the cases of amputation of the thigh, have been considerable. In a physiological point of view, this fact is remarkable, and shows that the blood-vessels can bear a suddenly-increased internal pressure, without any appreciable shock to the system, and without rupture of their walls. Further and more exact observation is needed, however, to conclusively determine the safety of the bloodless method in this respect; and it will perhaps be found that this distention of the vessels may be dangerous to persons suffering from organic diseases of the thoracic and abdominal viscera.

Although the cases in the table are too few for statistical purposes, they are numerous enough to settle many questions relating to Esmarch's method. And, in the first place, I may remark that it is perfect in its results, so far as the bloodless character of the operation is concerned. In an amputation of the thigh, for example, the limb can be removed, and the principal arteries secured, with the loss of only a few drops of blood; and, although the hæmorrhage from the smaller vessels may be tolerably free when the constricting band is unfastened, the bleeding is very trifling when compared with that which occurs during an amputation performed according to the ordinary method. In any case, the amount of blood lost to the general circulation can never equal that which has been gained by the employment of the bandage, so that, after the operation, the patient will have proportionately more blood than before. That this saving of the sanguineous fluid must be salutary in certain conditions, can hardly be doubted, and one of my own cases may be quoted as an example. A man was brought to the Bellevue Hospital, twelve hours after having had his foot crushed by the wheels of a railway-car. The

anterior tibial artery was wounded, and had bled so freely that the patient was in a fainting condition, and had no pulse at the wrist. Having administered stimulants by the rectum, I performed amputation of the leg by the bloodless method, and the patient made an excellent recovery. It is reasonable to infer that, if the operation had been attended with the usual loss of blood, the result might not have been so fortunate.

Patients with compound fractures are often brought into our hospitals while bleeding severely from injured blood-vessels; and the ordinary bandage, which is usually employed before they are brought to our notice, rarely suffices to check the hæmorrhage. The application of the elastic roller, in such cases, would frequently be the means of saving life; and a supply of these should be furnished to the ambulance-surgeons, and to those in charge of the police-stations, as they could be used with efficiency, even by the most inexperienced.

No argument is needed to prove the excellence of the method, in enabling the surgeon to have a clear and unobstructed view of the tissues that come under his knife; and this feature of bloodless operations is, to my mind, the one of greatest value. Every one has remarked how much easier it is to expose an artery or a nerve in the dead than in the living body. Now, this difference depends almost entirely upon the fact that, in the latter, the tissues are stained and altered in their appearance by the blood which escapes from the divided vessels. While the blood is still flowing, the parts are often completely concealed from view; but, even after the hæmorrhage has ceased, the tissues are not unfrequently so uniformly stained as to make their recognition a difficult task. In these circumstances, especially if the dissection is a deep one, precision in operating is often impossible, and injuries, both unavoidable and serious, are not seldom inflicted upon blood-vessels and nerves, even by skillful and cautious operators. In a bloodless operation, however, these difficulties vanish, as if by magic, and dissections may be made upon the living body, with a degree of precision heretofore unknown. The aid thereby afforded to the surgeon is incalculable, and the advantage to the patient is great and obvious. To one who has never before witnessed a bloodless operation, that for

necrosis of the femur in the popliteal space is, perhaps, one of the most striking. Instead of groping among tissues obscured by venous blood, and needlessly sacrificing the living bone, to permit the removal of the sequestrum, the operator can use his eye to guide the instrument at every step, distinguish at a glance the diseased from the healthy bone, and complete the operation with the least possible damage to the surrounding tissues. A medical friend, being present at such an operation, remarked to me that he had attended many operations for necrosis, but that this was the first one he had ever seen. In operations for caries of the joints too, particularly those of the hand and the foot, the bloodless method permits the surgeon to inspect the diseased parts with ease and satisfaction, and to determine, to a nicety, the extent to which these require to be removed. In doubtful cases, we may thus often substitute for an amputation the minor operation of excision, or even an exploratory incision into the affected tissues.

The table gives eight cases of the removal of tumors from deeply-seated parts. The particulars of these cases are somewhat meagre; but, with the exception of one in the practice of Dr. Ely, of Newburg, where the extirpation of the tumor necessarily involved the division of the large femoral vessels, and consequent amputation of the thigh, they all terminated successfully. In Dr. Wood's case, that of a tumor in the popliteal space, I presume the dissection was made more easy and certain by the employment of the elastic roller. Its advantages were plainly shown in a case that occurred in my own private practice. The patient, a lady, whom I saw in consultation with Dr. Dana, had a sarcomatous tumor about as large as a walnut, growing from the periosteum of the radius, near the upper extremity of the bone. To remove it, I was obliged to turn aside the superficial muscles, and to cut away a part of the supinator brevis. In doing this I exposed the posterior interosseous nerve to the extent of nearly an inch; but with care I dissected out the tumor without injury to the nerve. The wound healed in five days, by the first intention, and no paralysis followed. I feel confident that, had I not been able to avail myself of Esmarch's method, I should have



probably either divided the nerve, or excised it. While pursuing this line of remark, I would suggest a caution. The bloodless state of the parts, while it favors the recognition of most of the textures, renders the blood-vessels themselves, in consequence of their emptiness, somewhat liable to accidental division. Ordinarily, in operations such as are performed for the removal of deep-seated tumors, or for the ligation of vessels, both the arteries and the veins are easily recognized, the former, if at all large, exhibiting pulsation, and the latter revealing themselves by their size, color, and compressibility. But, when the bloodless method is employed, I have found that considerable care is required to avoid the unnecessary division of vessels—the veins, from the thinness of their coats, being especially liable to this accident. During the operation, therefore, the surgeon should make good use of his anatomical knowledge, and study the appearance of the tissues before he divides them. Otherwise, what is a bloodless operation in the beginning, may in the end be a very bloody one; and the operator may be chagrined to find, when the pressure of the cord is removed, that he has unwittingly severed one or more important vessels. Moreover, in any case, before the wound is closed, its surface should be scrupulously examined, lest a divided artery escape notice at the time, and shortly after prove the source of a more or less copious hæmorrhage. It is desirable to secure as many vessels as possible, before the pressure is remitted, as the capillary bleeding which occurs afterward considerably obscures the parts, and prevents the recognition of the arteries, unless they are spurting freely. With care, a great number of vessels may be secured with a trifling loss of blood, as is shown by a case of large mammary tumor, removed by Dr. Gouley, who has favored me with the following memorandum: “This tumor, which had been growing for eleven years, and was very large—weighing nine pounds—proved to be a large-cell sarcoma. Esmarch’s elastic bandage was so applied as to make firm pressure upon its entire surface; then the rubber tube was securely wound around its base, which was somewhat pedunculated. When uncovered, the tumor was softer than before, and its surface quite blanched. During the extirpation, not more than one ounce of blood es-

caped, and throughout the entire operation—thirty ligatures having been applied—the total loss of blood did not exceed eight ounces. The pressure upon the tumor, and at its base, was not continued for more than ten minutes. The patient recovered, the greater part of the wound healing by the first intention.”

Our table includes three cases of wounded arteries, in which the bloodless method was employed in searching for the injured vessel. In the first case, the ulnar artery, in the second, the superficial palmar, and, in the third, the anterior tibial, was the seat of lesion, and in all the vessel was found and secured. There can be no doubt that such operations are greatly facilitated by the employment of the elastic bandage. In traumatic aneurism also, in which the plan of laying open the sac is adopted, the difficulties of the operation, which are sometimes very great, must be nearly removed by the aid of Esmarch's method. A case of this character is related by Leisrink, who treated successfully a traumatic aneurism of the anterior tibial artery, situated in the upper third of the leg, by opening the sac, and tying the artery as it lay upon the interosseous membrane. Those who are aware of the great depth at which the artery is placed in the upper part of its course, will appreciate the assistance which the bloodless method must have afforded in this operation, which is stated by Leisrink to have been performed with ease.

To the Hunterian operation, as practised for idiopathic aneurism, the method is not applicable, as the artery can be exposed in the usual manner without difficulty, and as the pressure of the bandage might cause the rupture or inflammation of the aneurismal sac.

Finally, in this connection, it may be mentioned that, although there are no cases in the table to prove it, the bloodless method has been found serviceable in operations undertaken for the extraction of foreign bodies, such as pieces of needles or of glass, from the hand or foot. These parts are exceedingly vascular, and, when rendered bloodless, must permit a more precise and satisfactory exploration than could otherwise be made.

Another alleged advantage of the method, which finds no

illustration here, is the local anæsthesia which is said to accompany the state of local anæmia. A case is reported by Stokes, of Dublin, in which the extirpation of an epithelial cancer, from the back of the hand, was accomplished without pain. The effects of the ether-spray, when employed as an auxiliary, are also said to be very rapidly produced, because the arrest of the circulation in the parts prevents their natural warmth from being renewed. I am doubtful whether local anæsthesia, induced by these methods, can be obtained without some compensating disadvantage. Both the elastic bandage and the ether-spray cause considerable pain; and, when combined, would, as I fear, be very apt to occasion sloughing. The question, however, is one that will soon be determined by experience.

The table presented contains a number of minor operations, which require no comment. A novel application of the method, however, was made by Dr. Wood, who applied the elastic bandage in a case of elephantiasis of the thigh, with a satisfactory result. I hope that Dr. Wood, who is present, will communicate the particulars of this interesting case.

Having considered the advantages of Esmarch's method, as shown by the facts which I have collected, let us now try to determine whether they prove it to have any disadvantages. What I have to say may be put under three heads, namely, sloughing, secondary hæmorrhage, and paralysis.

Sloughing is reported to have followed in eight of the operations recorded in the table. Six of these operations were performed in the Bellevue Hospital, one in the Brooklyn City Hospital, and one in the Mount Sinai Hospital. It will be profitable to present you with an abstract of each one of these cases:

CASE I. Bellevue Hospital.—Male, aged fifteen. Primary amputation at knee-joint, for lacerated wound of leg. Slight sloughing of each flap, but not enough to prevent healing.

CASE II. Mount Sinai Hospital.—Boy, aged three years. Primary amputation, according to Syme's method, for a railway injury of the foot. A small part of the flap sloughed, but not enough to prevent the covering of the stump.

CASE III. Bellevue Hospital.—Male, forty-nine. Primary



amputation for lacerated wound of hand. The parts removed were the thumb and first metacarpal bone, the entire index-finger, and the second and third phalanges of the middle and ring fingers. Slight sloughing of the stump of the thumb and index-finger, but not enough to prevent healing, which was complete on the forty-second day.

CASE IV. Bellevue Hospital.—Male. Compound, comminuted fracture of tibia and fibula, with simple fracture of femur of same side. Amputation through condyle, by long anterior and short posterior flaps, close to the line of laceration. Severe hæmorrhage had preceded the operation. About an inch and a half of the anterior flap sloughed, but the stump finally healed.

CASE V. Brooklyn City Hospital.—Male, aged twenty-eight. Partial excision of carpal bones, for necrosis, resulting from a crushing injury received ten months previously. Two days after the operation, phlegmonous inflammation followed, with profuse discharge and sloughing, necessitating amputation of the arm. This was performed, and the patient recovered.

CASE VI. Bellevue Hospital.—A feeble woman, aged seventy. Primary amputation of arm, for compound, comminuted fracture of forearm. Some sloughing of one flap; erysipelas on seventeenth day; bed-sore, and death from exhaustion.

CASE VII. Bellevue Hospital.—Male, aged thirty-eight. Primary amputation at knee-joint, for compound fracture of bones of leg. The flaps were taken from parts infiltrated and contused. Spreading gangrene, which extended as high as the nipple; destroyed the patient on the fourth day.

CASE VIII. Bellevue Hospital.—Male, aged thirty. Amputation at middle of thigh, by long skin-flaps, for a large, malignant tumor of the femur. The patient was in feeble condition at the time of operation, and did not rally well afterward. About one-fifth of each flap sloughed, and death occurred on the third day.

CASE IX. Bellevue Hospital.—Male. Amputation above knee, for compound fracture of leg, caused by the wheels of a railway-car. Slight slough of outer flap, which did not prevent the healing of the wound.

On reviewing these cases, we find that seven of them were cases of primary amputation. As the whole number of primary amputations given in the table is forty-one, it follows that sloughing of the flaps occurred in seventeen per cent. So far as these figures are concerned, they prove nothing against the bloodless method; for it has been shown, by Dr. Figuera, that, at Bellevue Hospital, out of forty amputations, according to the old method, the flaps sloughed more or less in twenty-four, or sixty per cent.

Ten cases of sloughing are reported after secondary operations, these being nearly twelve per cent. of the entire number given in the table.

After a careful examination of the cases in which sloughing followed in primary amputations, I hardly feel willing to attribute the accident to the method employed. When we consider that some of these patients were intemperate, or feeble from loss of blood, that their injuries were severe, and that the flaps, which, in some cases, were very long, were generally taken from parts not far from the line of laceration, we are strongly inclined to regard these circumstances as the most important factors in the production of gangrene. It is, however, impossible to deny that the application of the elastic bandage may have had some share in causing this untoward event; and our suspicions are strengthened by the occurrence of gangrene in one case of amputation, which was not primary, inasmuch as gangrene, so far as my observation goes, is very rare in amputations performed for disease. In this case, amputation of the thigh was performed on account of a malignant tumor of the femur; and although the patient's general condition, prior to the operation, is stated to have been feeble, the gangrene of both flaps, which soon followed, compels us to suspect that the bloodless method may have been its determining cause. On the other hand, we must not fail to notice that the amputation was performed by long skin-flaps, which overhung, loosely, the end of the stump.

But the strongest case bearing upon this point is the one mentioned as having occurred in the Brooklyn City Hospital, and in which extensive sloughing followed an excision of the carpus. Dr. Speir, the attending surgeon, has kindly favored

me with his own views respecting this case, and I quote from his letter as follows: "There is no doubt, in my mind, that the use of Esmarch's method was the cause of the sloughing that followed the operation, in the case to which you refer. I do not hold the method responsible, however, for there was, perhaps, unnecessary pressure made by the constricting band, although it was not greater than I have used in other cases, in which no sloughing occurred. Less pressure would probably have been followed by a different result; and I find, by later experience, that less pressure would have been sufficient to have fulfilled the object of Esmarch's method. Therefore I cannot hold it responsible. The proof that the use of Esmarch's method was the cause of sloughing in the case referred to is, that in the amputation of the arm which followed—performed by Dr. Kissam, my successor in the hospital-service—I controlled the brachial artery myself, with the view of deciding whether the bloodless method, or the patient's condition, was to blame for the sloughing. After this operation, the wound healed almost by the first intention. Esmarch's method is certainly a most excellent one, and I should be sorry to have this case bring any discredit upon it. It takes a little time to learn how to apply the new method properly."

With these remarks I cordially agree. Should future experience show that the employment of the bloodless method is a frequent cause of gangrene, we shall be obliged to abandon it; for this objection, once well established, would be a fatal one. It is greatly to be hoped, however, that, by a careful application of the elastic bandage, we shall be able to secure the benefits which it unquestionably confers, without any compensating disadvantages; meanwhile it will be prudent to abstain from its employment in certain cases, and, above all, to learn the minimum degree of pressure that will accomplish the desired result. The bandage should be soft and highly elastic, and the constriction of the limb should be made either by a piece of the same material, or, where this would be too wide, by a piece of soft rubber tube. The solid cord should, I think, be abandoned, as likely to do mischief. In applying the constricting band, much less force is needed



than is commonly imagined, and with every additional turn the effect is considerably increased. Finally, the operation ought not to be needlessly prolonged. It is not easy to determine, however, for what length of time the state of artificial anæmia may be maintained with impunity; as, in several cases in the table, the elastic bandage was applied for an hour, and, in one case of amputation of the thigh, for one hour and forty minutes, without injurious consequences. Doubtless, however, the danger increases with the length of time the pressure is continued; and in amputations—which are shown to be the operations most likely to be followed by gangrene—the bandage need not be kept on longer than five or ten minutes. As bearing on the question of the cause of sloughing after the use of the elastic bandage, it may be well to bear in mind that, with a single exception, sloughing occurred only in amputations.

I have been unable to discover, in the cases of operation that were not followed by sloughing, any failure or imperfection in the reparative process, which could be ascribed to the method employed. The wounds have presented the ordinary character, and many of them have healed by the first intention.

Hæmorrhage is reported in four cases in the table, as follows:

CASE I. Bellevue Hospital.—Male, aged forty. Operation for necrosis of lower end of femur. The wound, which was situated on the inner side of the limb, was deep, and bled pretty freely when the operation was concluded. It was plugged with lint, but the hæmorrhage persisted until the fourth day, when the wound was reopened, and a bleeding artery discovered, which was supposed to be the anastomotica magna. This was tied, and no further hæmorrhage occurred.

CASE II. Bellevue Hospital.—Male, aged ten. Primary amputation of thigh at junction of lower and middle thirds. Shortly after the operation, bleeding took place from the medulla, and was arrested by the actual cautery.

CASE III. Bellevue Hospital.—Male, aged twenty-seven. Partial amputation of the hand, for a severe crushing injury, received four days previously. After the operation, the limb

was immersed in hot water. A week later, a hæmorrhage occurred, which did not exceed two ounces. The patient was terribly frightened, and died three hours after.

CASE IV. Bellevue Hospital.—Male, aged twenty-one. Amputation of arm for compound fracture of forearm. Oozing of blood for some time after the operation prevented the adhesion of the flaps, but the wound healed by granulation.

In none of these cases, so far as I am able to judge, was the bleeding fairly attributable to the employment of Esmarch's method, and I am therefore disposed to dismiss, as invalid, the assertion that the method predisposes to the occurrence of hæmorrhage.

We find in the table only one case of paralysis; but this was well-marked, and occurred on the day following an operation, performed at the Roosevelt Hospital, for necrosis of the humerus. The operation was performed on February 9th. The constriction of the arm was effected by a solid rubber cord, but the duration of its application is not stated. February 10th.—Complete motor paralysis in forearm and hand. Tactile sensibility in finger greatly diminished. March 13th.—Examined by Dr. Seguin. Total motor paralysis of forearm and hand still remains. Electricity was applied, and the patient speedily improved. When he left the hospital, on May 10th, he had almost entirely regained the movements of flexion and extension, and partly those of supination and pronation.

Besides this case of paralysis, we find one of neuralgic pains, continuing for two weeks after an operation, performed at the Mount Sinai Hospital, for necrosis of the scapula.

The above are the only cases in which nerve-symptoms followed the employment of the bloodless method, and there can be no doubt that the mischief was caused by the undue pressure of the constricting cord. Langenbeck has reported three cases of paralysis of the median nerve, due to the same cause; and he suggests that an elastic bandage be used as a means of constriction, instead of the tubing or solid cord. This suggestion is a practical one, and its adoption will, it is to be hoped, prevent a repetition of the accident referred to.

We have no facts to enable us to prove the danger of

rupture of the blood-vessels, from the pressure of the constricting cord, and it seems probable that such danger is no greater than when the tourniquet is employed. Finally, the caution which has been urged against the application of the elastic bandage over gangrenous parts, or over those which are the source of putrid discharges, is undoubtedly a wise one, and, so far as I can learn, has generally been observed by operating surgeons.

Enough has been said to prove that Esmarch's bloodless method is one of the most valuable surgical expedients that have been devised in modern times. It only remains, now, to determine the best mode, and the proper range, of its application.











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